Weather and Radar Processor (WARP) Mission Need Statement

March 1995

I. ADMINISTRATIVE INFORMATION

A. Title: Weather and Radar Processor (WARP)

B. MNS Number: 84

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D. Originator's Organization: ASE-100

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F. Sponsor's Organization: AAT- 1

G Sponsor's Focal Point: Daphne Jefferson, ATR-136

H. Sponsor's Focal Point Phone Number: 202-267-8278

I. Revision Number: 2

J. Submission Date: February 20, 1992

K. Revision Date: March 30, 1995

II. DESCRIPTION OF THE MISSION

National Transportation Safety Board and FAA statistics indicate that approximately 40 percent of aircraft accidents and 65 percent of air traffic delays of greater than 15 minutes are caused by weather. Air traffic controllers have an essential need for real-time weather information to carry out their primary mission of safely sequencing and separating aircraft within their assigned airspace. The Air Traffic Weather Requirements Team (ATWRT) report (February 11, 1993) reaffirms the need for weather data conversion and for tailoring of information for particular operational use. Pilots require the same information in order to safely navigate efficient routes through controlled airspace. Traffic Management specialists and supervisors require accurate, reliable information on current and forecast weather conditions to safely and efficiently regulate the flow of aircraft within the National Airspace System (NAS). The following information is required for both air traffic controllers and traffic management specialist/supervisors:

- Controllers require depiction of radar weather information on their surveillance displays.
- Controllers require advance notice of approaching or developing weather and its severity in order to make tactical and strategic decisions to safely route and meter traffic before hazards are encountered.

- Controllers of aircraft operating at lower altitudes where significant weather and related hazards are more prevalent require fine resolution of the intensity and location of hazardous weather to determine the impact on a specific air carrier or general aviation aircraft.

- Traffic management specialists and supervisors require current long-range weather detection (approaching weather, storm tracks, precipitation intensity) and forecasts for strategic planning of runway configurations and airport capacity.

- Accurate forecasts of the extent and duration of severe weather conditions that will reduce the handling capacity of major airports are needed to better anticipate the need for metering and for destination changes.

- Accurate reports of the extent and duration of severe weather, e.g., intense precipitation and turbulence, are needed in order to select jet routes and flight levels which will minimize the exposure of aircraft to potential hazards.

The mission of the center and central flow weather service units (CWSU and CFWSU) meteorologist is to support traffic management and other air traffic control (ATC) users by analyzing a wide range of official weather measurements, reports and forecasts to identify weather conditions that may adversely impact ATC and aircraft operations. The resulting meteorologist created warnings and advisories must be immediately disseminated to controllers and traffic managers to enable the safe separation and sequencing of aircraft. Frequent updates from a multitude of weather sensors and reporting stations within the NAS must be merged and analyzed so that ATC users may be promptly notified of deviations from previous CWSU/CFWSU forecast guidance. An automated weather data processing capability is required for timely meteorologist analysis of the enormous volume of available weather information and reporting of weather hazards to ATC users. This need has been documented in Order 1812.7, the System Requirements Statement for the CWP, approved by the FAA administrator on 8/12/85.

The required weather support services consist of the following major capabilities:

1. Continuous acquisition of all available real-time weather measurements pertaining to the area of interest.

2. Acquisition of official weather observations, reports and forecasts as available.

3. Detection of potential weather hazards with prompt notification to the meteorologist.

4. Graphic workstation display manipulation functions for rapid presentation and analysis of weather conditions.

5. Graphic and textual product generation and dissemination capabilities for communicating hazards to ATC users, including providing radar weather information for display on controller surveillance displays.

The timely reporting of weather conditions along flight routes [i.e., upper air winds, storm tops, precipitation intensity, pilot reports (PIREPS)] to controllers and pilots can only be achieved by deployment of advanced weather sensors, meteorological data processors, communications and display subsystems within the NAS. While the FAA will benefit from National Weather Service (NWS) modernization efforts by receipt of more accurate and timely forecasts of atmospheric conditions, additional FAA-unique processing capability is required in order for such products to be of use to controllers, supervisors and specialists. In accordance with the ATWRT report and the central weather processor (CWP) requirements, en route air traffic controllers need weather information with improvements in the following major functional categories:

Information Collection:

1. Applicability - Aviation weather products shall be tailored specifically to facilitate air traffic control specialists (ATCS) in tactical and strategic decision-making process. ATCSs are concerned with the operational effects of the weather phenomena as opposed to the weather characteristics themselves. Controllers need altitude specific radar information versus the fan-beam presentation currently available from surveillance radars.

2. Scope - ATCSs require weather information within and adjacent to their area of responsibility. Airspace boundaries are expected to be more flexible in the future, [e.g., automated en route air traffic control (AERA)] and other benefits accrue from an ability to extend situation awareness.

3. Accuracy and Quality - The accuracy and quality of weather information/data shall be sufficient to support the level of operational decisions being made.

4. Weather Severity Index - A more objective, quantifiable description and assessment of hazardous weather (e.g., icing and turbulence) is needed. Severity indices shall be stratified such that they can be related by all users to aircraft type. Accurate spatial extent, temporal duration, , and the rate of change of these quantities are highly desirable.

5. Forecasting - Weather prediction must be accurate and timely. Examples of forecast products include storm tracking information, National Weather Service forecasts, and CWSU meteorologist products. Forecast products shall have sufficient lead times to support both tactical and strategic operations.

6. National Meteorological Center Products - Products generated by the NWS's National Meteorological Center (NMC) shall be received and provided to the meteorologist for inclusion in his analysis and forecasting process.

7. Site Tailoring - Weather detection and forecasting systems shall have a capability of being tailored to specific sites to accommodate seasonal and geographic variances of meteorological phenomena and conditions.

Information Dissemination:

1. Data Timeliness - Weather data is highly perishable and must reach controllers, supervisors, and specialists within a time limit appropriate to its operational use.

2. Consistency - Controllers, supervisors, specialists, meteorologists, and pilots must have access to weather information derived from a common data base. Weather products provided to controllers must be consistent with information sent to pilots via data link.

Information Display:

1. Weather Condition Changes - ATCSs and pilots shall be informed of operationally significant weather changes. Redisplay of salient weather parameters shall be available to the ATCSs upon request.

2. Integrated Function - Detailed weather information must be displayed so it complements and supports other mission critical data. For example weather radar mosaics should be suitable for integration with controller and pilot displays. This includes support for CWSU meteorologist in the creation of graphical outlines of current and potential weather hazards, formatted in the NAS coordinate plane for ATC personnel.

3. Merged Weather Products - Groups of weather information, such as reflectivity products and storm point products, must be made available in a single product to enhance operational situational awareness.

4. Graphics - Graphical depiction must aid in the assimilation of large amounts of similar and dissimilar information, where appropriate. Examples include a mosaic of weather radar products and hazardous weather area outline products, oriented in the NAS coordinate plane and presentation of real-time weather information to CWSU meteorologists for manual analysis and identification. Graphical products that are displayed to ATCSs and pilots shall require minimal user interpretation or analysis.

5. Graphics Movement - Future position plots of weather areas shall be available to aid in the simulation of weather for aircraft routing decisions.

6. <u>Three-Dimensional Representation</u> - The ability to display weather events, phenomena, and/or conditions in three dimensions must be available where appropriate.

7. <u>Color Attributes</u> - Color shall be used judiciously to facilitate the recognition of development of weather conditions without masking surveillance information.

8. <u>Blinking and Audio Alert Information</u> Blinking and audio alert shall be provided, but shall be active only when armed by the user. Additionally, when audio alert is armed by the user, it shall be self-silencing after a user adjustable period of time. Controls for brightness of display and volume of audio shall be provided.

9. <u>Alerts and Alarms Thresholds</u> - The operator shall be able to activate and adjust alert and alarm threshold levels.

10. <u>Overlay</u> - Weather products must be available for overlay on surveillance data in a way that does not interfere with mission-critical functions. These products must be capable of being overlaid on target displays to enable quick and accurate correlation of aircraft and weather. Returns from multiple sensors must be combined to provide the most precise unambiguous depiction of hazardous weather.

11. <u>Individual Flight Tailoring</u> - The flight service personnel shall be provided with pre-flight and in-flight weather displays tailored to the specific flight.

12. <u>Contraction Translation</u> - A glossary that defines contractions and acronyms used in the notice to airmen (NOTAM) information messages shall be provided.

I. RATIONALE FOR THE ACQUISITION

A. CURRENT CAPABILITY:

1. <u>Description:</u> Precipitation intensity is currently the only weather information depicted graphically on the controllers sector display. This information is derived from surveillance radars, not from weather radars. Forecasts and other weather advisories are available in briefings, hard-copy or as relayed by supervisors. Additionally, pilot reports of recently experienced weather conditions are used by controllers to confirm the sector radar display of weather and to advise other aircraft approaching the hazardous area. Weather data processing capabilities include:

   a. <u>Weather data acquisition</u> - Real-time weather reflectivity data from the air route or airport surveillance radar (ARSR/ASR) digitizer is provided to controllers. In the en route environment, the range locations at which reflectivity exceeds one of two intensity thresholds are provided, radial by radial, to the host computer system (HCS) with a third threshold to be added by 1994.

Manual surface weather observations are received by the HCS hourly from reporting stations within the area control facility (ACF) area and as special reports, issued when conditions warrant. Official terminal forecasts and other significant weather warnings are also received from the NWS. Manual intervention is required to filter such data, extracting and forwarding only those messages pertinent to aviation and within the air route traffic control center (ARTCC) or terminal radar approach control (TRACON) airspace.

b. Weather data processing - Precipitation intensity data received from the ARSR is transformed in the HCS to the NAS coordinate plane of the target display and formatted as required by the display channel. No meteorological quality control or analysis processing is performed. Data level reports are converted to display vectors and special symbols used to represent the area boundaries of each of the two reflectivity intensity levels. Strategic weather analysis and hazard identification are performed manually by the CWSU meteorologist using the meteorologist weather processor (MWP) element of the CWP Program. The MWP also provides the capability for the meteorologist to create graphic depiction of current and potential weather hazards.

c. Weather data dissemination - Weather radials and symbols from individual ARSRs are received by the HCS via dedicated channels. This data is provided to controllers every 2 minutes. Controllers independently control the display of each of the two intensity levels, permitting them some control over the correspondence of the display with subject aircraft. Hard-copy pilot reports, surface observations and forecasts are also provided. Graphic and textual hazard warnings and advisories created by the CWSU meteorologist are displayed on briefing terminals provided by the MWP for en route traffic management specialists and area supervisors.

The mission of the MWP is being fulfilled by the MWP system, leased from Harris Corporation until January, 1995. The MWP service will be extended until it can be replaced by WARP in September 1997. MWP deployment, in ARTCCs and at the air traffic control system command center, was completed November, 1991. MWP automates the collection and synthesis of weather information required by the CWSU meteorologist in order to view, analyze and report weather phenomena that represent certain or potential hazards to aviation. It provides the following major capabilities:

d. Data acquisition - Leased telecommunications lines deliver precipitation measurements every two minutes from NWS and FAA long range radars directly to each of the ARTCC MWPs. Manual surface observations, geosynchronous satellite data and official NWS warning and forecast products are received via satellite relay from the Harris communications hub facility.

e. Meteorological workstation - Dual color displays are provided for the simultaneous display of graphic and alphanumeric weather data. Alarms are provided to promptly notify the meteorologist when selected observation thresholds are exceeded or urgent reports are received. Graphic depiction of surface observations or other alphanumeric data may be selected, via a mouse and on-screen menu, for overlay combination with satellite and radar data facilitating visual correlation and analysis. Such displays may be zoomed, panned, animated or otherwise manipulated by the meteorologist as required for analysis. Graphic and text annotation and product generation capabilities are provided to assist the meteorologist in preparation of warnings and advisories for ATC users.

f. <u>Warning/forecast dissemination</u> - Advisories and warnings created by the meteorologist are electronically disseminated to the weather message switching center (WMSC) and are displayed to traffic management personnel via briefing terminals, along with forecast and sensor data, to support flow control in the ARTCC and at the air traffic control system command center.

The next-generation weather radar (NEXRAD) principal user processor (PUP), to be installed between December 1991 and February 1994, will augment the MWP, providing routine access to advanced Doppler weather radar products and alerts from a single NEXRAD radar and requested, dialed access to individual products from any other NEXRAD.

2. <u>Deficiencies:</u> - Programs are being researched, developed and implemented to improve weather measurement, communication, dissemination and display for tactical use by controllers, flight service and pilots. These programs will improve the timeliness, quantity, quality and consistent dissemination of NAS weather information, and will be the first step to bring the NAS into compliance with the weather needs identified in the ATWRT report. NEXRAD weather radars are being installed at a cost of more than $250 million in order to provide much better weather information. However, the benefits associated with these enhancements cannot be fully realized without the implementation of advanced weather data processing technology. In addition to this general deficiency in the current NAS modernization procurement efforts, the following specific deficiencies limit the effectiveness of weather-related control actions:

a. <u>Lack of comprehensive data</u> - The ARSR and ASR are surveillance radars, operating with a fan beam, and neither can provide detailed, accurate weather measurements over the typical 125 mile radius of a true weather radar. Each reports a gain-weighted integration of weather returns at all heights, exaggerating precipitation intensity and range extent. Low-lying hazards cannot be distinguished from upper air disturbances without height data. The ARSR was designed to minimize weather sensitivity in order to maximize surveillance range. Range and azimuth smoothing limit weather positioning accuracy and the few thresholds available provide only a coarse measure of precipitation intensity. The ASRs ability to detect precipitation is limited to the immediate area of the airport terminal, and its precipitation detection accuracy diminishes greatly, for the outer limits of coverage (45-60 miles from the radar site). No Doppler measurements are provided to enable identification of wind hazards (mesocyclones, tornadoes, shear turbulence).

b. Lack of meteorological processing - The HCS provides only coordinate conversion and symbolic presentation processing of the radar weather data. In both the ARTCC and TRACON controller presentations, no analysis is provided to identify weather hazards such as severe storm cells, hail or other related phenomena. The controller must rely on pilot reports for identification of specific weather. Scan-to-scan changes in the position of high reflectivity are the only indication of storm motion available. No consistency-checking or compositing of overlapping radar data is performed. The lack of automated storm cell identification and alert processing of current data from multiple weather radars seriously limits the timeliness of CWSU manual hazard identification.

c. Limited dissemination - Forecasts and other alphanumeric weather data must be manually reviewed by a meteorologist to determine their usefulness to a given sector. They cannot be continuously posted to serve as a ready reference for controllers, cannot be automatically relayed to pilots, and must be retrieved or recalled in each case. Such manual processing limits the effectiveness of this information, particularly under heavy workloads. Hazard advisories, warnings and outlines issued by the CWSU are not available at the sector position except by supervisor manual relay. Visual correlation of identified hazards with targets is not possible. Manual processing of such warnings also degrades data timeliness. Controllers cannot obtain near-real-time surface observation data or upper air wind information. Operational impacts of weather are not identified for controllers or supervisors.

d. Termination of MWP - The termination of the MWP contract, with the base period ending October, 1992 and options expiring January, 1995, is itself a major deficiency since no program or funding is in place to ensure continuity of support for the continuing CWSU mission. A contract to provide extension of MWP functions is being pursued to provide continued coverage until WARP can be procured. MWP also has the following specific deficiencies:

(1) No central flow MWP access to National or ACF radar mosaics; no ATCSCC display of information from more than one radar.

(2) No interfaces for acquisition of new products from advanced weather sensors.

(3) Key NEXRAD products (e.g., storm point data) will not be available commercially due to lack of commercial access to full NEXRAD data. They can be displayed individually on a PUP but cannot be overlaid on MWP for analysis.

(4) Lack of plotting and processing of gridded upper air winds and temperature forecast data and pilot reports.

(5) No interfaces for dissemination of CWSU warnings and advisories to new NAS user subsystems or status to the maintenance processing system (MPS).

B. PLANNED CAPABILITY: A WARP will be deployed in the ACF to serve as the prime source of real-time tactical and strategic weather data for controllers, pilots and meteorologists. The WARP must provide regional real-time weather support at each ACF. This function will involve support for ATC en route and terminal operational domains. WARP products will be disseminated to controllers, segmented by geographic area and altitude as required by the user. Identical data will be directly communicated to aircraft via Data Link or by voice broadcast. The major functions of this system will be:

Comprehensive weather data acquisition - To detect weather phenomena within the ACF airspace, the WARP will acquire real-time advanced Doppler weather data including high resolution precipitation, upper air wind field measurements and severe storm identification and tracking data. Visual and audible alerts will be provided to the meteorologist at the WARP graphics terminal. Mosaics and other weather radar products may also be displayed on this monitor. At the NEXRAD's site, the precipitation data obtained will be formatted in six finely-resolved intensity levels representing the highest intensity detected in each of three vertical layers over the detection range, nominally 125 nautical miles. These radars are automatically and continuously calibrated to ensure the accuracy of their measurements. A hazardous rainfall intensity, from a specific location and height, will be reported instead of the smoothed, integrated ARSR measure. This precipitation data from the radar will be received for discrete altitude bands which will permit weather conditions impacting approach/departure and light aircraft operations to be distinguished from upper air disturbances affecting primarily en route operations. The NEXRAD, dedicated to weather surveillance only, will identify individual storm cells and storm height and will detect extreme phenomena such as hail or organized cyclonic winds. It will project cell tracks for up to an hour.

The WARP will also receive minute-by-minute automated surface observations, identical to those broadcast continuously to pilots. NWS upper air gridded model data, pilot reports, specific to the ACF airspace, as well as NWS forecasts will be acquired from the weather message switching center replacement (WMSCR).

Enhanced meteorological processing - Product data from all NEXRADs within the ACF airspace coverage (the largest ACFs will have over twenty NEXRADs) will be processed by the WARP to form mosaics of precipitation and turbulence in altitude bands. Mosaic data is automatically selected from operational NEXRADs that contribute to coverage of ACF airspace, using a predetermined priority ranking based on the radar's ability to resolve the column of air over a given grid position. The continuous automatic calibration common to all NEXRADs will ensure the consistency of measurements acquired from multiple sites. The overlapping coverage of the received NEXRAD data also will provide redundancy to support a high availability for the WARP service to the NAS. Automatic WARP intervention is also provided to adjust the selection of data from NEXRADs in the event that an individual radar failure risks corruption of the data. The WARP will transform the NEXRAD data to the NAS coordinate plane, in which aircraft targets are displayed.

Storm cell hazard identification products from multiple NEXRADs will also be composited by the WARP into an ACIF-wide mosaic. Reports on the same storm ceil received from multiple overlapping radars will be compared by the WARP and the most critical conditions will be incorporated into the storm point mosaic. The projected track and attributes, such as hail or mesocyclone, will also be included in the mosaic. All NEXRAD products received by the WARP will be compared with thresholds pre-selected by the meteorologist, who will be notified immediately upon detection of potential hazards above those levels. Graphic workstation display manipulation functions will support the meteorologist in rapid analysis of weather conditions. Manually-created CWSU graphical hazard warnings are also transformed to the NAS coordinate plane.

The WARP will receive weather data from the automated weather observing system (AWOS) and the automated surface observing system (ASOS) via the AWOS data acquisition system (ADAS). The WARP will process pilot reports and other alphanumeric products to improve their value as quick reference aids to controllers. The WARP will also transform upper air wind and temperature forecast data to provide hourly projections of expected conditions and selected flight levels and grid positions.

Weather data dissemination - The WARP will disseminate real-time mosaic data to controllers for depiction on surveillance displays. Minute-to-minute surface observation data will be forwarded upon reception at the WARP. Reformatted alphanumeric weather products needed by controllers to provide weather support services to pilots will also be transmitted. Textual and graphic weather hazard warnings and advisories created by the meteorologist, upon alert by the WARP, will be disseminated to controllers, pilots and other ATC users for overlay and correlation with targets.

Enhancements over MWP - WARP enhancements of MWP capabilities include:

1. Display of National and ACF radar mosaics at central flow WARP.

2. Acquisition of new weather surface observation (AWOS/ASOS), satellite (GOES-NEXT), lightning and NEXRAD products.

3. Improved workstation and briefing terminal analysis support and display capability including plotting of gridded data and PIREPs.

4. NAS interfaces for dissemination of CWSU warnings and advisories to ATC users and to MPS for status reporting.

5. Improved aviation weather products based on FAA-sponsored NMC gridded forecast model improvements.

6. Use of new products developed by the National Center for Atmospheric Research (NCAR) utilizing new weather sensor and weather radar data.

7. Alarms and alerts of significant weather changes to users.

8. Overlay of weather products with radar target display to provide for routing of air traffic to avoid weather hazards.

9. Merged weather products, such as reflectivity products and storm point products to enhance operational awareness.

10. Graphical depiction of weather products to facilitate meteorologist analysis of weather, and display of weather products to the user, that require <u>minimal</u> user interpretation.

11. Future position plots of weather areas displayed for ATCSs for routing decisions.

12. Tailoring of products for the specific area of interest.

The WARP will serve as the FAA's gateway for NEXRAD information to NAS users, and it will provide a platform upon which certain initial aviation weather research (AWR) functional capabilities can be implemented. Additionally, it will supplement the limited central services currently offered by the MWP by providing automated weather products and displays.

C. <u>PROPOSED ALTERNATIVES:</u> The following methods of procuring the WARP functions have been examined:

1. <u>Separate Real-time Weather Processor (RWP) and MWP</u> This is the comparison baseline.

   a. Advantages.

      (1) A prototype RWP has been developed, documented, and tested. This strategy takes maximum advantage of the prototype software.

      (2) The system components and interfaces are baselined in the NAS.

(3) Problems associated with lack of commercial capability for RWP functions are avoided.

b. Disadvantages.

(1) It is more expensive to support two systems than one. It is especially inefficient when the systems are as closely related and even somewhat overlapping as are the RWP and MWP (e.g., both provide weather radar mosaics, but to different users).

(2) Even if the RWP and MWP, functions could be cleanly separated with no overlap, there would remain an appearance of overlap. This introduces an element of programmatic risk.

(3) The market now offers at least some of what RWP was originally intended to do. This redefines the difference between non-developmental items (NDI) and developmental capabilities, which was the definition of MWP and RWP. There is no longer as strong a justification for separate systems.

(4) Government development is costly, risky, and time-consuming. However, this disadvantage is largely mitigated by the fact that an RWP prototype has already been developed, documented, and tested.

c. Expected Performance: All required capabilities could be obtained.

2. <u>NDI WARP Plus Interfaces</u> This strategy combines RWP and MWP into an NDI WARP except with NAS interfaces to be developed by the vendor. This strategy would allow some weather information to reach controller displays, a key RWP characteristic.

a. Advantages.

(1) Schedule: Fastest final (very limited) capability.

(2) Cost: The least expensive strategy (but there is no NDI source for some functions beyond interfaces).

b. Disadvantages. Performance: No NDI vendor system can perform all required functions, even given the development of the interfaces.

c. Expected Performance: the following requirements would not be met.

(1) Timeliness of radar information.

(2) Request reply for non-routine products.

(3) Custom layer composites of radar products.

d. Discussion: The inability of this strategy to meet all WARP requirements effectively eliminates it as a viable option. It is carried forward only for comparison purposes as the closest strategy to pure NDI.

3. NDI WARP Plus Development This strategy combines RWP and MWP into an NDI WARP with some functions and NAS interfaces to be developed by the vendor.

a. Advantages. Cost. Potentially the least expensive fully capable strategy (depending on who chooses to bid).

b. Disadvantages.

(1) Cost/Schedule Risk: The amount of development required (and therefore the acquisition cost and the final capability date) will depend largely on which vendors bid and which is selected. The results are not predictable.

(2) Programmatics: It is not clear that this strategy is contractually acceptable. The extent to which NDI can be modified is not well defined, but to achieve full capability, a significant change in vendor architecture might be required.

c. Expected Performance: Depending on the degree of development allowed, a capability up to the full required level could be achieved.

4. NDI WARP Plus FAA System This strategy combines RWP and MWP into an NDI WARP. For some functions, an FAA system would be developed to handle the non-NDI functions.

a. Advantages: Problems associated with lack of commercial capability for RWP functions are avoided.

b. Disadvantages.

(1) Schedule: Full capability (the developmental portion) is subject to extensive delay.

(2) Cost: The FAA developmental portion would eclipse the cost of the NDI portion.

(3) Risk: Development of the FAA system would carry risk similar to that of the RWP. If interfaces with the NDI portion were attempted without modification to the NDI system (i.e., based on whatever external interface comes with NDI), then interface development would carry high risk. If the strategy is adopted to modify the NDI system for interfaces, then this strategy is virtually identical to the baselined strategy of separate RWP and MWP systems.

(4) Programmatics: It is not clear that this strategy meets the definition of combining RWP and MWP into a single system. For all practical purposes it would be the baselined system, except with a name change and perhaps some RWP functions being allocated to the NDI portion.

c. Expected Performance: Full capability could be achieved.

5. Developmental WARP This strategy combines RWP and MWP into a fully developmental WARP.

a. Advantage: Cost. Potentially the least expensive fully capable strategy (depending on who chooses to bid).

b. Disadvantages: Cost/Schedule Risk. The amount of development required (and therefore the acquisition cost and the final capability date) will depend largely on which vendors bid and which is selected. The results are not predictable.

c. Discussion: It is likely that the winning bidder would start from an NDI platform. If so, some cost and risk would be reduced. However, this is beyond government control other than through selection of the winning proposal.

d. Expected Performance: Full capability could be achieved.

IV. IMPACT OF DISAPPROVING THE ACQUISITION

Disapproval of WARP acquisition would principally reduce the tactical and strategic decision making proficiency of air traffic controllers, supervisors, and traffic management specialists located at en route centers. The safety and delay reduction benefits attributed to the real-time accuracy, reliability, and comprehensiveness of the data available to controllers and meteorologists would be lost and current deficiencies would persist. The improved weather data that was made available by spending more than $250 million would not be realized. Weather data used by controllers would be lacking in applicability, scope, accuracy and quality, weather severity identification, forecasting, timeliness, consistency, integration with ATC data, merger of weather data, graphics, three-dimensional representation, and overlaying.

Without the WARP, there would be no capability in the NAS to depict weather hazards for tactical and advisory use by air traffic controllers. The ARSR reflectivity data would remain the only indicator of weather for the en route environment. Further investment in extending the remaining life of the ARSR-3 weather equipment would likely be required. A 1993 MITRE study comparing ARSR weather data with NEXRAD data identified significant ARSR weather deficiencies. Also, the NCAR study *ARSR/NEXRAD Comparison Study Phase One*, prepared for the FAA and published December 15, 1992, concluded that the NEXRAD is more accurate than ARSR for all weather products, even if NEXRAD data update is limited to once per volume scan and even more superior if expanded to updates for each tilt scan. The report further concluded that the NEXRAD's superiority increased with altitude, being most profound above 33,000 feet - the typical air carrier en route domain. The existing network of NWS radars is being decommissioned as the NEXRAD is fielded, leaving no alternative weather radar.

Disapproval of the WARP will result in a termination of the service currently provided by MWP to traffic management (TM) specialists and supervisors. Without timely weather information and current and forecast conditions of specific concern to aviation displayed at their positions, the TM specialists and supervisors will lose the ability to regulate air traffic flow as safely and efficiently as they do today. Controllers and pilots will be deprived of time-critical warnings and advisories of current or developing hazardous weather conditions. The CWSU and CFWSU meteorologists will be required to manually organize and analyze large amounts of received weather data. seriously limiting the timeliness and comprehensiveness of the briefings and warnings provided to ATC users.

The specific consequences of the disapproval of WARP production are:

1. Safety - The margin of safety for en route weather hazard avoidance would be reduced by the postponed/canceled introduction of advanced weather radar information in NAS ATC operations. The ability to reroute aircraft around hazardous weather conditions would be diminished or eliminated for lack of timely information.

2. Capacity - More conservative spacing and rerouting of aircraft required due to continued poor definition of areas of hazardous weather would significantly limit capacity improvements. The ability of the TM to anticipate weather patterns affecting traffic flow would be diminished or eliminated, resulting in an inability to accurately project capacity and route traffic accordingly.

3. Cost - Additional processor capability would be required in display system replacement (DSR) or elsewhere to provide weather information to controllers. Significant enhancement of or design changes to other NAS weather/user subsystems would be required to provide equivalent services to CWSU and TM users.

4. Technical - The addition of two or three new direct weather sensor-to-NAS automation interfaces would be required. Limited or no automated CWSU meteorologist workstation support would be available to generate and disseminate meteorologist created weather products.

5. Support - Enhancement of ARSR-3 weather equipment may be needed to maintain existing radar weather support well into the next decade.

V. RESOURCE REQUIREMENTS

The estimated cost of the WARP procurement was calculated to be $126.4 million (in current year dollars) for facilities and equipment (F&E). The full life cycle cost is $227.8 million (in current year dollars) including operations and maintenance (O&M) costs, or $211.2 million when an O&M savings of $16.7 million resulting from the removal of NEXRAD PUPs is included. The O&M estimate also includes a hardware replacement in FY 2003-2005 time frame. A fiscal year spread of the most likely cost for the recommended approach is shown in Table V-1 in current year dollars.

A) Fiscal Year Spread: - The fiscal spread in current year dollars is shown in Table V-1. The maximum, minimum and most likely costs are shown in current year dollars in Table V-2 and in constant 1994 dollars in Table V-3.

In summary the estimated most likely cost of WARP in millions of current year dollars is:

	FY 96 & Prior	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01	FY 02 & Out
F&E	2.2	7.8	28.2	29.6	293	21.2	8.1	
O&M						*2.8*	*6.6*	*92.0*

B) Basis of Estimate: - The estimates for the costs were derived from a combination of comparisons with similar systems, known costs of existing commercial systems, estimates of adding FAA interfaces, and a parametric analysis of software development to support the FAA interfaces and the developmental items.

C) Included in Estimate: - Table V-3 lists the items that were included in the cost estimates for the NDI WARP Plus Development system.

VI. RECOMMENDATIONS

The Acquisition Executive should approve the WARP mission need and grant approval to proceed with acquisition phase three.

VII. **SIGNATURE PAGE**

NPI SUBMISSION:

Monte R. Belger Bill Jeffers 3/16/95

Sponsoring Organization (Associate Level)	Bill Jeffers, AAT-1 Director of Air Traffic	Date

Mission Need Statement Approval:

The following actions are requested for the Weather and Radar Processor Program:

(a) Approve the WARP Mission Need Statement.

(b) Approve KDP-3 decision to proceed with full scale development and limited production of the WARP.

Lon. C. Ezekiel 3/27/95 J. L. Lt 3/20/95

Performing Organization (Director Level)	Jack Loewenstein, AND-400 IPT Leader for Surveillance/Weather	Date

Greg L. Horsch 5/5/95

(Acquisition Review Committee Approval) Date

TABLE V-1 WARP LIFE CYCLE COSTS

FISCAL YEAR SPREAD, Most Likely Estimate ($ Millions) CURRENT DOLLARS

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL
F & E																		
WARP Stage 0		0.4	3.8	5.7	6.0	3.5												19.3
Systems Engineering	1.4	0.4	2.7	2.7	2.8	2.9	3.0	1.0										17.9
SW Development			0.5	5.9	9.1	8.6	10.2	1.4										35.7
Vendor Contract Management			0.8	1.7	1.7	1.8	0.9	0.9										7.8
Engineering/Config Dev/Mgmt				1.5	0.8	0.1	0.1											2.5
Hardware				6.4	4.0	4.1												14.4
LTD Prod MX Contract				0.3	0.3													0.6
COTS SW/SW Licenses				0.0	0.1	0.1												0.3
Freight				0.2	0.1	0.1												0.4
HW Install/Test/Evaluation				0.3		0.7	0.2											1.2
SW Install/Test/Evaluation					1.9	2.9	1.1	4.5										10.4
Initial Spares						0.7												0.7
Initial Operations Training				0.2	0.2	0.2	0.1	0.2										0.9
Comm Installation/Hook-up				0.2	0.5	0.8	1.8											3.4
Initial Leased Comm(1 year)				0.2	0.3	0.5	1.1											2.1
Data/documentation				1.3	0.2													1.5
Pre-Production Data Service				0.1	0.2	0.3												0.5
Pre-Production Utilities/Facilities				0.0	0.0	0.0												0.1
Initial Maintenance Training				1.5	1.5													3.0
Initial HW Maintenance(2 years)						1.6	1.7											3.3
Initial SW Maintenance(1 year)						0.3	0.9											1.2
TOTAL F & E:	1.4	0.8	7.8	28.2	29.6	29.3	21.2	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	126.4
O & M (10 YEAR LIFE CYCLE)																		
Rent, Utility & Other							0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	2.1
Data Service							1.0	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.1	0.1	12.2
Recurring Operations Training							0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	1.2
Communications (Recurring)							0.9	2.2	2.2	2.3	2.4	2.4	2.5	2.6	2.7	2.1	0.1	22.3
HW Maintenance Contract								0.3	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.3	0.1	12.3
Software Maintenance							0.5	1.6	2.2	2.4	2.3	2.3	2.4	2.5	2.6	1.3	0.7	20.7
FAA Line Maintenance								0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	1.1
Replenishment Spares								0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.8
Inventory Management								0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Sustaining Investment								0.7	0.7	5.2	5.4	5.5	5.7	0.5	0.5			24.2
Recurring Maintenance Training							0.1	0.3	0.3	0.3	0.6	0.7	0.3	0.4	0.4	0.3	0.0	3.7
Recurring Travel							0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.7
TOTAL O & M:	0.0	0.0	0.0	0.0	0.0	0.0	2.8	6.6	8.6	13.5	14.2	14.5	14.4	9.5	9.8	6.6	0.9	101.4
WARPTOTAL COST	1.4	0.8	7.8	28.2	29.6	29.3	24.0	14.7.	8.6	13.5	14.2	14.5	14.4	9.5	9.8	6.6	0.9	227.8
NEXRAD PUP O&M Averted								-1.4	-1.5	-1.6	-1.7	-1.9	-2.0	-2.2	-2.3	-1.9	-0.1	-16.7
TOTAL PROGRAM COST	1.4	0.08	7.8	28.2	29.6	29.3	24.0	13.3	7.1	11.9	12.5	12.6	12.4	7.4	7.5	4.7	0.8	211.2

TABLE V-2 WARP LIFE CYCLE COSTS – KDP-3 UPDATE
($ Millions, Current Year)

COST ELEMENT	LOW	MOST LIKELY	HIGH
F & E			
WARP Stage 0	$14,482.7	$19,308.9	$23,960.1
Systems Engineering	$13,110.8	$17,014.3	$24,979.2
SW Development	$17,910.3	$35,685.3	$72,154.6
Vendor Contract Management	$6,395.4	$7,844.0	$9,122.9
Engineering/Config Dev/Mgmt	$1,717.0	$2,528.8	$3,339.6
Hardware	$8,980.0	$14,397.6	$23,830.9
LTD Prod MX Contract	$276.8	$561.8	$1,056.8
COTS SW/SW Licenses	$0.0	$294.2	$441.3
Freight	$269.4	$431.9	$714.9
HW Install/Test/Evaluation	$552.9	$1,182.0	$2,445.6
SW Install/Test/Evaluation	$5,198.7	$10,382.9	$21,448.5
Initial Spares	$371.8	$745.2	$1,541.8
Initial Operations Training	$775.0	$911.8	$1,561.5
Comm Installation/Hook-up	$2,762.1	$3,419..4	$4,190.2
Initial Leased Comm (1 Year)	$1,720.1	$2,102.7	$2,577.8
Data/Documentation	$786.2	$1,492.7	$2,395.5
Pre-Production Data Services	$415.4	$488.7	$610.9
Pre-Production Utilities/Fac Cost	$62.0	$82.7	$110.2
Initial Maintenance Training	$2,546.6	$2,996.0	$4,326.4
Initial HW Maintenance (2 Year)	$1,698.3	$3,328.0	$6,259.7
Initial SW Maintenance (1 Year)	$704.3	$1,187.5	$1,486.6
TOTAL F & E:	**$80,735.6**	**$126,386.3**	**$208,554.9**
O & M (10 YEAR LIFE CYCLE)			
Utilities/Facilities Costs	$1,542.0	$2,056.0	$2,741.4
Data Service	$10,333.1	$12,156.6	$15,195.7
Recurring Operations Training	$775.6	$1,216.7	$2,083.7
Communications (Recurring)	$18,243.2	$22,301.0	$27,339.7
HW Maintenance Contract	$6,206.9	$12,296.5	$24,876.1
Software Maintenance	$10,346.4	$20,697.3	$40,752.4
FAA Line Maintenance	$579.3	$1,093.0	$2,035.5
Replenishment Spares	$331.0	$751.5	$1,583.0
Inventory Management	$165.5	$300.6	$678.4
Sustaining Investment	$13,457.5	$24,219.8	$40,088.6
Recurring Maintenance Training	$2,345.9	$3,679.8	$5,367.9
Recurring Travel	$531.6	$664.5	$886.1
TOTAL O & M	**$64,858.1**	**$101,433.3**	**163,628.2**
NEXRAD PUP O&M Averted	($21,038.5)	(16,667.6)	($14,153.2)
NET TOTAL O&M	**43,819.6**	**$84,765.7**	**$149,475.0**
TOTAL COST	**$145,593.7**	**$227,819.6**	**$372,183.1**
NET PROGRAM COST	**$124,555.2**	**$211,152.0**	**$358,029.9**

TABLE V-3 WARP LIFE CYCLE COSTS – KDP-3 UPDATE
($ Millions, 1994 Constant)

COST ELEMENT	LOW	MOST LIKELY	HIGH
F & E			
WARP Stage 0	$13,115.5	$17,505.4	$21,741.8
Systems Engineering	$10,395.0	$13,860.0	$20,790.0
SW Development	$15,782.1	$31,135.2	$62,880.9
Vendor Contract Management	$5,637.5	$6,914.4	$8,041.7
Engineering/Config Dev/Mgmt	$1,550.0	$2,282.9	$3,014.9
Hardware	$8,041.9	$12,893.6	$21,341.5
LTD Prod MX Contract	$250.3	$508.0	$955.6
COTS SW/SW Licenses	$0.0	$260.0	$390.0
Freight	$241.3	$386.8	$640.2
HW Install/Test/Evaluation	$482.5	$1,031.5	$2,134.1
SW Install/Test/Evaluation	$4,451.0	$8,781.4	$18,003.4
Initial Spares	$321.7	$644.7	$1,333.8
Initial Operations Training	$672.4	$791.0	$1,354.7
Comm Installation/Hook-up	$2,373.0	$2,937.7	$3,599.9
Initial Leased Comm (1 Year)	$1,477.8	$1,806.5	$2,214.7
Data/Documentation	$719.4	$1,365.9	$2,192.1
Pre-Production Data Services	$366.3	$430.9	$538.7
Pre-Production Utilities/Fac Cost	$54.7	$72.9	$97.2
Initial Maintenance Training	$2,302.7	$2,709.1	$3,912.1
Initial HW Maintenance (2 Year)	$1,447.5	$2,836.6	$5,335.4
Initial SW Maintenance (1 Year)	$600.6	$1,004.4	$1,258.5
TOTAL F & E:	**$70, 283.2**	**$110,158.8**	**$181,771.1**
O & M (10 YEAR LIFE CYCLE)			
Utilities/Facilities Costs	$1,132.3	$1,509.8	$2,013.0
Data Service	$7,587.7	$8,926.7	$11,158.3
Recurring Operations Training	$566.3	$888.4	$1,521.4
Communications (Recurring)	$13,300.3	$16,258.6	$19,932.1
HW Maintenance Contract	$4, 462.3	$8,828.8	$17,860.8
Software Maintenance	$7,541.4	$15,015.4	$29,513.5
FAA Line Maintenance	$416.5	$784.8	$1,461.3
Replenishment Spares	$238.0	$539.5	$1,136.6
Inventory Management	$119.0	$215.8	$487.1
Sustaining Investment	$9,904.2	$17,825.0	$29,503.8
Recurring Maintenance Training	$1,712.8	$2,686.8	$3,919.3
Recurring Travel	$390.4	$488.0	$650.6
TOTAL O & M	**$47,371.3**	**$73,967.4**	**$119,157.9**
TOTAL COST	**$177,654.4**	**$184,126.2**	**$300,929.0**
NEXRAD PUP O&M Averted	($15,065.5)	(11,974.2)	($10,195.2)
NET PROGRAM COST	**$102,588.9**	**$172,152.0**	**$290,733.7**
ESCALATED F&E	**$79,335.6**	124,986.2	$207,145.9
ESCALATED LCC	**$123,155.2**	**$209,752.0**	**$356,629.9**
DISCOUNTED LCC	**$69,488.2**	**$113,110.7**	**$188,174.8**